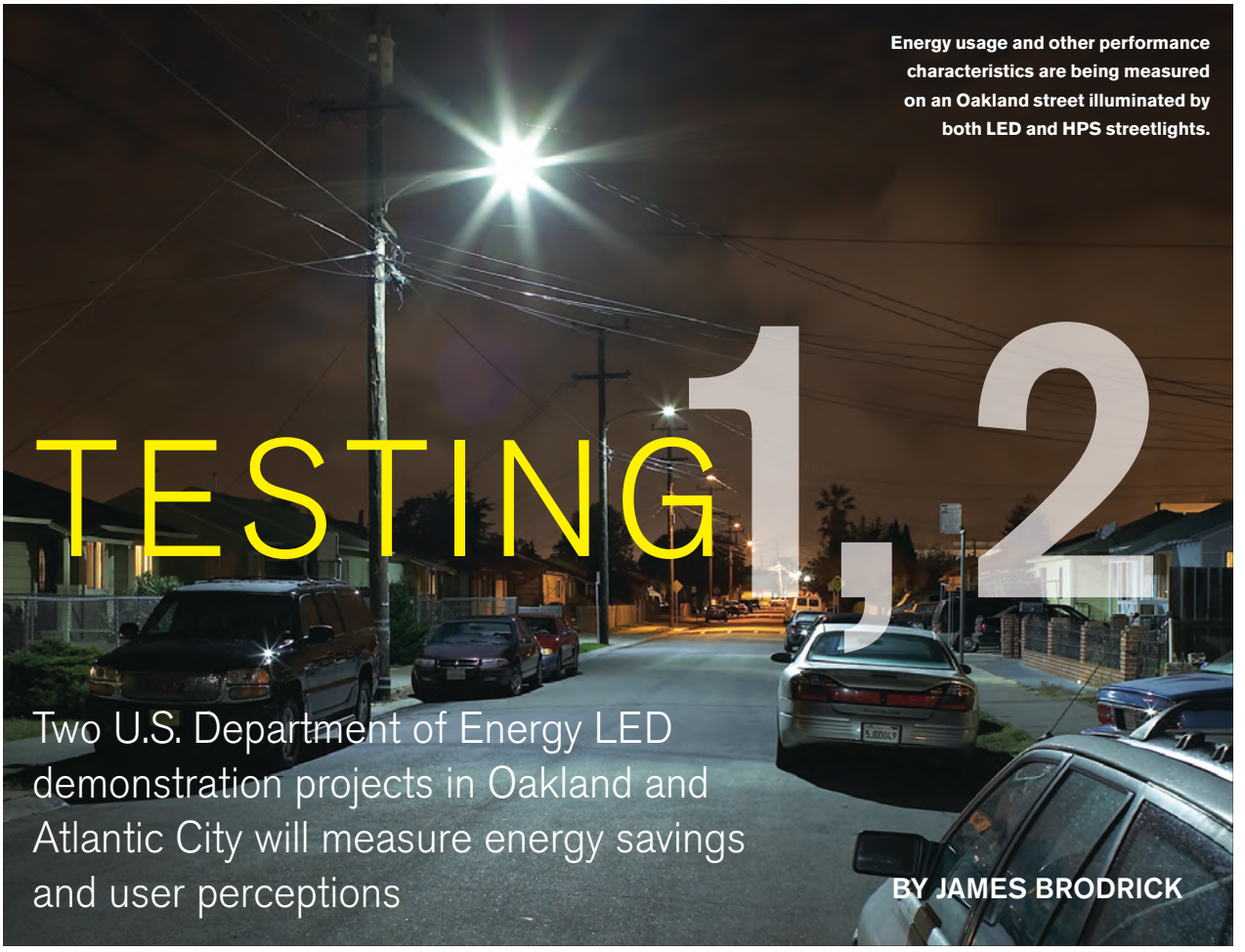

Energy usage and other performance characteristics are being measured on an Oakland street illuminated by both LED and HPS streetlights.

TESTING 1, 2

Two U.S. Department of Energy LED demonstration projects in Oakland and Atlantic City will measure energy savings and user perceptions

BY JAMES BRODRICK

In Oakland, CA, the lighting of three adjacent streets might give passersby a reason to pause. One is illuminated entirely by high-pressure sodium (HPS) streetlights, one with LEDs and the third is a mix: half LEDs and half HPS. If you stand in the middle of this third street and look either way, you can easily discern the difference between the two types of lighting: the yellow light of the HPS versus the white light of the LED. Driving the length of the street and experiencing the lighting change halfway offers a stark comparison. It's all part of a U.S. Department of Energy (DOE) Solid-State Lighting Technology Demonstration project that links the City of Oakland, Beta LED, Pacific Gas & Electric Company (PG&E) and DOE's Pacific Northwest National Laboratory (PNNL) in a partnership to demonstrate the current suitability of LED solutions for general illumination in selected applications.

OAKLAND–AN EARLY ADOPTER

Oakland was chosen as a demonstration site because of the city's large number of outdoor lights and its history as a leader in energy efficiency. According to Oakland's Public Works Agency director Raul Godinez II, the city has long been an early adopter of cutting-edge technologies; it was quick to adopt red LED traffic signals in 1999 and green ones in 2001, as soon as the luminaires were approved for use.

Oakland currently has 35,000 streetlights consuming 22 million kilowatt-hours of energy annually; this accounts for about one-third of the municipality's electricity costs. The city's goal, says Godinez, is a streetlight system that creates safety and security at the lowest energy cost while minimizing greenhouse gas emissions.

Beta LED of Racine, WI, was one of a dozen manufacturers to offer its products to DOE for the demonstration

program. Its modular outdoor LED luminaires fit the Oakland demonstration needs well. DOE had the luminaires tested by an independent laboratory to verify the luminaire efficacy and color characteristics of the units. See **Figure 1** for the laboratory test results.

BETA LED Area Light (parking) with 5 light bars	Total Watts	Output Lumens	Luminaire Efficacy	CCT	CRI
	116	6272	54	5948	76

Source: Independent laboratory testing (not parking lot testing) of product samples for the DOE Solid-State Lighting Technology Demonstration program.

Figure 1. Pre-Demonstration Laboratory Test Results

Streetlights operate for long periods–typically 12 hours or more every night of the year. While HPS is often used for street lighting because of its longevity, LEDs offer some distinct advantages. In laboratory testing, the Beta LED luminaires demonstrated a CRI of 76 (Figure 1), far exceeding the traditional HPS CRI of 22. In addition, LEDs are more efficient and last even longer in the cooler operating temperatures that usually prevail at night. The Beta LED luminaires are convection-cooled, which further reduces the operating temperature of the luminaire.

Before agreeing to a full demonstration on city streets, Oakland engineers first tested the LED luminaires in a city-owned parking lot to compare the LEDs to the HPS lamps currently in use. Prior to installation on a public roadway, they wanted to determine if there was excess glare or any inadequacy in the LED light distribution (dark spots or lack of uniformity) that could pose problems for drivers. The engineers installed three poles with Oakland's standard 100-W HPS streetlights and seasoned (burned in) the lamps for more than 100 hours to provide a baseline for comparison to the LEDs. PG&E's Emerging Technologies team subcontracted Energy Solutions, Inc. to take illuminance and power measurements. The luminaires with HPS lamps were then replaced with Beta LED's "The Edge" luminaires for comparison. After a week, the measurements showed the average illuminance provided by the LEDs to be higher than that from the HPS lamps. Oakland engineers reported no observable increase in glare. **Figure 2** details illuminance results from the parking lot testing.

The luminaires use modular light bars, each bar containing 20 1-W LEDs. Several of these modular units can be installed in a given luminaire to provide the level of light needed for a specific application. Originally, the products provided for laboratory testing and the parking lot demonstration contained five light bars, resulting in a 121-W power draw for the parking lot demonstration. This exceeded the 110-W power draw of the HPS fixtures, but provided 56 percent higher average illuminance at the parking lot surface.

The manufacturer recommended installing fewer light bars to achieve an optimal balance between illumination levels and reduced energy consumption. By the time of the official installation in October, Beta LED was able to install luminaires using just three light bars. The projected illuminance from the LEDs should be the same as the HPS, while saving 35 percent of the energy consumed. In the three months between the July lab testing and the October installation, a new generation of LED chips increased the luminaire efficacy from 54 lumens per watt to 59 lumens per watt, a 10 percent increase in light output.

The final demonstration involved 15 LED luminaires–10 on the LED-only street and five on the LED/HPS street. In addition to taking field measurements, the team gathered feedback from neighborhood resi-

	LED Illuminance				HPS Illuminance			
	Average (fc)	Max (fc)	Min (fc)	Uniformity Ratio	Average (fc)	Max (fc)	Min (fc)	Uniformity Ratio
Photopic	0.53	1.49	0.09	16:1	0.34	1.30	0.09	14:1
Scotopic	1.04	2.97	0.19	16:1	0.23	0.84	0.00	>9:1

Source: Energy Solutions monitoring results; final report to be issued by DOE in 12/07, www.netl.doe.gov/ssl/techdemos.htm

Figure 2. Oakland Parking Lot Test Results - Illuminance

Photo: City of Oakland

Photo: Beta LED

Before and after photos highlight the visual contrast between HPS street lighting (left) and LED street lighting (right).

dents to get their impressions of the various lighting options. These questionnaires provided subjective data in addition to photometric measurements.

Results of the demonstration, including photometric data, resident feedback, energy and maintenance savings data, return-on-investment estimates and recommendations on how to proceed will be published by DOE in December 2007. The final report will be available for download at *www.netl.doe.gov/ssl/techdemos.htm*. The city will continue to look at issues such as color rendering, public perception, system efficiency, return on investment and life cycle costs as it considers the role of LED street lighting.

City of Oakland Demonstration	
Location	City of Oakland, California
Partners	City of Oakland, Beta LED, Pacific Gas & Electric, Pacific Northwest National Laboratory
Current technology	100 W HPS cobra-head fixtures, 90 degree medium cutoff, Type III distribution, flat glass lens, magnetic ballast mounted at 28.5 feet above finished grade
Measured energy use of HPS luminaire	450 kWh per year
LED technology	Beta LED "The Edge" 3-bar area luminaires
Projected energy use of LED luminaire	300 kWh per year
Projected energy savings potential	Approximately 150 kWh per year per 100 W HPS lamp replaced

ATLANTIC CITY PILOT PROJECT

A second DOE Technology Demonstration features a similar Beta LED product installed on seven lighting poles along a walkway near the Federal Aviation Administration (FAA) William J. Hughes Technical Center in Atlantic City, NJ. According to Jessica Soper, a Lockheed Martin program analyst for the FAA Energy Program in Washington, D.C., the Hughes Technical Center campus houses a variety of testing facilities and is often used as a demonstration site for products the FAA is investigating. For FAA, the ease of installation and total cost, including maintenance and energy cost savings, are the key factors in determining the success of this demonstration.

The existing lighting arrangement in the testing area consists of seven 70-W HPS post-top fixtures mounted on 14-ft poles with a tripod connector, spaced on a grid approximately 35 ft by 25 ft. The prevailing maintenance procedure is to replace lamps as they burn out, which is typically more expensive than group relamping on a fixed replacement schedule.

Obtaining baseline photometric data for the existing 30-year-old-plus fixtures was challenging, since no known data existed. Beta LED obtained an existing fixture from FAA to submit for lab testing prior to the demonstration. The company will explore using only two light bars in each luminaire for this demonstration; if this configuration is considered sufficient to improve visibility in the walkway area (and indications are that it will be), it will draw only 48 watts of power compared to the 70-W HPS lamps.

For the demonstration, FAA will first relamp and clean the existing HPS luminaires. After the lamps have been seasoned (100 hours burn-in), illuminance and power measurements will be taken to provide an

accurate baseline for comparison with the LED products. After the measurements are taken, FAA will replace the HPS luminaires with LED luminaires. Illuminance and power measurements will be taken again for the new luminaires.

PNNL will prepare a summary of the comparative illuminance and power measurements. After two weeks of LED usage, they will distribute questionnaires to users of the facility to gauge reactions to the LED lighting, specifically any perceived improvement or reduction in visibility. Feedback from nighttime security personnel who routinely patrol the walkways is considered particularly important.

At the end of the project, PNNL will assemble the demonstration results, including photometric data, user feedback from the questionnaire, energy savings data and an associated simple payback analysis into a final report. According to Soper, if the demonstration shows a return-on-investment of 10 years or less, the FAA will consider further procurement of LED products.

MORE TO COME

The Oakland and Atlantic City demonstrations are the first of many DOE Solid-State Lighting Technology Demonstrations; more are planned for 2008 and beyond. The U.S. Postal Service is investigating Beta LED Wall Pack luminaires to replace HPS fixtures around its building perimeters. LEDs may help the USPS meet newly issued building design standards for performance and life-cycle costs.

Not all DOE demonstrations will focus on exterior applications. In Washington, D.C., the Smithsonian Museum of Natural History and OSRAM SYLVANIA are discussing a possible demonstration of museum display lighting. The potential energy and maintenance cost savings make a strong argument for LED display cases that operate 12 hours a day, 363 days a year. LEDs would also prevent the artifacts from being exposed to damaging UV and IR radiation emitted by conventional light sources.

Schneider Homes near Seattle, WA, is considering inclusion of residential undercabinet LEDs from OSRAM/Belfer Lighting and LED downlights from LED Lighting Fixtures in its showcase home kitchens. A number of Pacific Northwest home builders have expressed similar interest.

Photo: City of Oakland

The luminaires use modular light bars, each bar containing 20 1-W LEDs. Luminaires configured with three light bars (left) were used in Oakland.

Federal Aviation Administration Demonstration	
Location	FAA William J. Hughes Technical Center in Atlantic City, NJ
Partners	FAA, Beta LED, Pacific Northwest National Laboratory
Current technology	70 W HPS post-top luminaires mounted with a tripod connector at 14 feet above finished grade
Estimated energy use of HPS luminaire	370 kWh per year
LED technology	Beta LED "The Edge" 2-bar area luminaires
Projected energy use of LED luminaire	200 kWh per year
Projected energy savings potential	Approximately 170 kWh per year per 70 W HPS lamp replaced

The DOE Solid-State Lighting Technology Demonstration program will continue to match host sites with appropriate LED products to demonstrate and investigate the suitability of LED solutions for general illumination applications. DOE issued a second "Invitation to Participate" for LED manufacturers in November 2007. For more information on participating in DOE demonstrations, visit the DOE website at *www.netl.doe.gov/ssl/techdemos.htm.*

About the Author: James Brodrick is the lighting program manager for the U.S. Department of Energy, Building Technologies Program. The Department's national strategy to guide high-efficiency, high-performance solid-state lighting products from laboratory to market draws on key partnerships with the lighting industry, research community, standards organizations, energy-efficiency programs, utilities and many other voices for efficiency.